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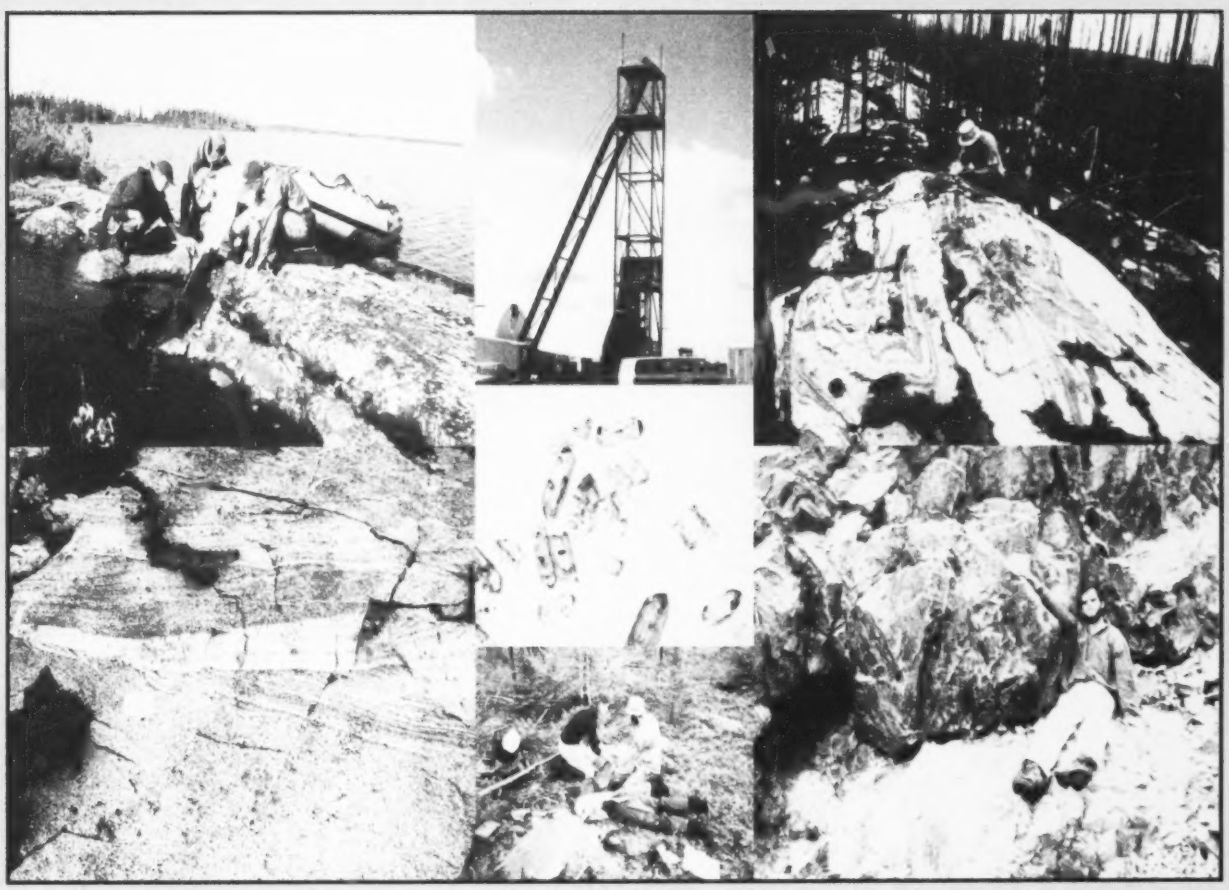
Geological Survey

December 1 to 3, 2003

Open House 2003

Abstract Volume

Saskatchewan Geological Survey



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Cover:
Centre: Analyzed zircons from 1751 ±2 Ma pink fluorite-bearing porphyritic granite from Spratt Lake in the northern Mudjatik domain (see Heaman *et al.*, this volume).
Clockwise from upper left:
Geological assistants learn how to measure a fold axial plane at Phelps Lake (Kim Bailey, Derek Savage, Dave Cedergren, and Chelsey Ebel) (see Harper *et al.*, this volume)
Headframe at Shore Gold's Star Kimberlite Project.
F_2 folds in mixed supracrustal rocks near Rottenstone Lake (see MacLachlan, this volume).
Malachite and azurite staining associated with copper mineralization at the west end of White Lake (22 km northwest of Uranium City), Zemlak Domain (see Ashton *et al.*, this volume).
Till sampling in the Dobson Lake area, northwest of Patterson Island, Reindeer Lake, Peter Lake Domain Project (see Campbell, this volume).
Cross-bedded igneous layering in the circa 2.56 Ga Swan River Complex of the Peter Lake Domain. It formed near the bottom of a magma chamber, where increased fluid shear stress (a function of velocity and pressure in the magma chamber) within the intrusion causes rhythmically layered dunes and scours. The interior of the pluton, is to the top of the picture. Another world-class example of primary layering, rivalling those seen in the 'cross-bedded belt' of the Skaergaard Intrusion; west side of small bay north of Patterson Island on Reindeer Lake (see Maxeiner and Leatherdale, this volume).
Photos by staff of Saskatchewan Industry and Resources.

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Note: Authors are Saskatchewan Industry and Resources staff unless otherwise indicated in the abstracts.

Session 1: Athabasca Uranium – EXTECH and Beyond

EXTECH IV Athabasca Uranium – Post-project Integration Highlights

C.W. Jefferson [1], G. Delaney, R.A. Olson [2], P. Portella [3], and D. Thomas [4]

Jefferson, C.W., Delaney, G., Olson, R.A., Portella, P., and Thomas, D. (2003): EXTECH IV Athabasca uranium – post-project integration highlights; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper D-1.

Abstract

By the close of the 2000-2003 EXTECH IV partnership project (part of the Targeted Geoscience Initiative), 15 sub-projects had addressed two goals: a) to improve Athabasca Basin geoscience knowledge in well explored and frontier areas; and b) to enhance/develop EXploration TECHnology for discovery of world class uranium orebodies such as P2 North at McArthur River. Unconformity-associated uranium deposit models had been evaluated and extended by addressing these goals. Results and impacts had been reported annually in workshops, field trips, published summaries of investigations, and conference presentations.

Post-project activities have focused on preparation of a formal volume sponsored by Mineral Deposits Division of the Geological Association of Canada, Saskatchewan Geological Society and Earth Sciences Sector of Natural Resources Canada. Production of this volume and a related metallogenic synthesis are parts of the new Western Churchill Metallogeny Project. Integration of results from the 15 EXTECH IV sub-projects has improved understanding of many exploration parameters that are already impacting exploration and development in the Athabasca Basin uranium mining camp, as follows.

Before EXTECH IV, key exploration targets included fundamental structural-stratigraphic interfaces in basement domains, faults offsetting the unconformity with the overlying Athabasca Group (quartzose sandstones of uncertain Proterozoic age and paleo-environmental setting), graphitic conductors in the basement close to these faults, enigmatic basement highs under the thick sandstone cover, and various forms of local to regional mineralogical alteration. EXTECH IV was designed to examine such targets, with the inherent question of why combined ore grades and tonnages here are orders of magnitude greater than unconformity-related uranium deposits elsewhere in the world. Interplays among basement tectonics, local structures, sedimentation, diagenesis, and hydrothermal alteration have now been spatially and temporally linked to concentrations of uraninite that are being mined at or near the interface between the basal unconformity and reactivated graphitic basement fault zones.

Athabasca stratigraphy and the western basement framework have been resolved across the Alberta-Saskatchewan border, documenting Taltson Magmatic Zone lithotectonic assemblages and isotopic signatures as far east as the southern segment of the Snowbird Tectonic Zone in Saskatchewan. The eastern basement relationships between the Wollaston and Mudjatik domains were initially enhanced by provincial geological mapping and have now been linked, by detailed structural analysis of two open pit mines, to late brittle deformation associated with uranium mineralization. Enigmatic ribbon-shaped K-U anomalies identified from re-processed airborne gamma ray data have been re-assessed from perspectives of Quaternary geological-geochemical processes and basement influences.

Regional lithologic and sequence stratigraphy, sedimentology, seismic reflection and potential fields transects, and areal analysis of these data have resolved mapping discrepancies, and demonstrated active syn- to post-sedimentary faults, uplifts and downwarps that target prospective regions. Geochronology of detrital and diagenetic minerals has constrained tectonic timing, a late Paleoproterozoic age for the Athabasca Group, and supported correlations with other basins at continental (Thelon-Hornby-Muskwa basins) to intercontinental scales (Australia). Detailed analysis of the Athabasca Group using the same above-listed tools at McArthur River and Cluff Lake has documented local tectonic-sedimentary processes that are specifically related to mineralization, in particular: paleo-valleys, growth faults (alternating reverse/normal faults), basement uplifts (flower structures), and changes in basin slope through time. Brittle deformation favoured pre-established basement structures took place episodically before and during sedimentation, continued after lithification, and is associated with extremely complex, pervasive to enveloping hydrothermal alteration such as silicification, de-silicification, boron metasomatism, and clay alteration. Paleoproterozoic hydrocarbon generation, migration, and fixation are documented and variably

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associated with orebodies, but as a post-ore phenomenon, as are Phanerozoic hydrocarbons that migrated throughout the basin and into basement.

Selected coincident exploration targets, both regional and property-specific, have been quantitatively evaluated by testing and further developing various geophysical tools. Seismic reflection images directly outline the unconformity, fault zones, and alteration zones. Patterns are interpreted in places as complex basement structural highs that were developed by compressive deformation during sedimentation. High-resolution gravity detected density differences related to alteration and basement configuration. Magnetotelluric surveys have detected deep basement conductors and silicified zones in the Athabasca Group, and borehole geophysics has provided the link between geological and geophysical rock properties, impacting all of the other sub-projects including detailed stratigraphy and ore grade estimation. GIS databases are capturing raw and processed results for geoscientific audiences.

EXTECH IV Athabasca Uranium – Seismic Integration Highlights

D.J. White [1], Z. Hajnal [2], I. Gyorfi [2], E. Takacs [2], B. Roberts [1], C. Mueller [1], B. Reilkoff [2], R. Koch [3], B. Powell [4], I. Annesley [5], and C. Card

Abstract

Regional and high-resolution seismic reflection studies have formed a central part of the EXTECH-IV Athabasca uranium project. The seismic data have been interpreted with other geophysical and geological information resulting in an improved exploration model for the McArthur River camp and demonstration of the potential of seismic methods for deep exploration within the Athabasca Basin. Highlights of these results include: 1) demonstrating the 3-D complexity of the ore-bearing P2 fault zone; 2) identifying fault-controlled structures associated with the P2 fault; 3) evidence for syn-tectonic deposition within the upper parts of the Athabasca Group; 4) imaging fault-related rotation of sedimentary beds; 5) mapping of the basal unconformity/regolith including variations in character, offsetting faults, and paleotopography; 6) identification of silicified zones using seismic velocities; 7) revealing the internal architecture of the polydeformed high-grade Archean/Paleoproterozoic basement complex; and 8) providing constraints on the regional tectonic/structural framework of the region. Following official project completion, research will continue to fully exploit currently under-utilized components (e.g., 3-D and multi-component) of the seismic program.

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SHRIMP U-Pb Geochronology of Apatite Cements and Zircon-bearing Tuff Clasts in Sandstones from the Athabasca Group, Athabasca Basin, Northern Saskatchewan and Alberta

R.H. Rainbird [1], N. Rayner [1], and R.A. Stern [1]

Abstract

This research is part of the Geochronology sub-project of the EXTECH IV – Athabasca Uranium Multidisciplinary Study and was an attempt to obtain chronostratigraphic constraints on deposition of the Athabasca Group. Previous studies indicate that phosphate (apatite and xenotime) cements are present at several stratigraphic levels of the Athabasca Group. Samples of the Wolverine Point (WPb) and Manitou Falls (MFd) formations, provided by Paul Ramaekers, were examined using SEM and standard petrographic methods to establish the extent and nature of phosphate mineralization. Xenotime typically occurs as tiny (1 to 10 micron) euhedral overgrowths on detrital zircons and is best developed in the MFd sample, a quartzarenite from the Riou Lake area in the northwest part of the basin. The xenotime appears to have formed during early diagenesis as it is overgrown by early quartz cements and by pore-filling apatite cement. SHRIMP U-Pb analysis of xenotime was inconclusive owing to very low U and Pb concentrations and meaningful ages could not be obtained. It is probable that hydrothermal fluids scavenged these elements, although this is considered unusual. Apatite cements in the same sample occur as blocky grains with hematite intergrowths in interstitial regions; in places, it invades and replaces matrix and framework quartz grains. SHRIMP U-Pb analysis of multiple grains of the apatite yielded a $^{207}Pb/^{206}Pb$ age of 1638 ±12 Ma (2σ). Several grab samples from the unconformably overlying WPb Formation, in the central part of the basin, contain pervasive apatite cements that show similar petrogenesis to those from the MFd Formation. SHRIMP analysis of several grains from four different samples yielded a $^{207}Pb/^{206}Pb$ age of 1625 ±17 Ma (2σ). This age is within error of the MFd age and thus the apatite in both samples is considered to represent the same episode of mineralization. During our SEM sessions, intraclasts of tuffaceous siltstone, common in several of the WPb samples, were discovered to contain several 10 to 30 micron euhedral zircons. The zircons are interpreted to be of igneous origin and SHRIMP analysis yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 1644 ±13 Ma (2σ). Although the tuff intraclast age is statistically within error of the ages from apatite cements we consider that it approximates the age of deposition for the WPb and therefore that the apatite cementation occurred shortly after deposition of the WPb.

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Results of a Transient Magnetotelluric Survey on Line WAS-4: Comparison with DC Resistivity and Gravity Data

David K. Goldak [1] and Rodney R. Koch [2]

Abstract

Thunderstorm activity produces large amounts of electromagnetic energy which is trapped within the earth-ionosphere waveguide. The random sum of energy from activity on a near global scale produces a low-level quasi-continuous source field. Very large, or equivalently, relatively nearby lightning discharges produce individual transient events whose amplitude are significantly larger than that of the low-level background field. Therefore, substantial increases in signal-to-noise ratio can be realized by recording exclusively sources of a transient nature. However, the transient events are strongly linearly polarized, the polarization diversity of which can affect the estimation of earth response curves.

It has been shown that an adaptive time domain averaging of the transient waveforms results in earth response curves whose bias converges to zero super-exponentially in stacked signal-to-noise ratio.

*A transient audio-magnetotelluric (TAMT) survey conducted with the EMPulse AMT system in the Shea Creek area of northern Saskatchewan demonstrates the efficacy of the algorithm based on the results obtained. Thirty-six sites at 100 m spacing were collected with the impedance tensor **Z** and the magnetic field tipper **T** estimated over the bandwidth 8 Hz to 32 kHz.*

Two-dimensional inversion of the TAMT data has revealed two distinct conductors on line WAS-4. The strongest conductor is aligned near station 25W at a depth of approximately 700 m. A second weaker conductor is evident 1.8 km to the east at station 7W at slightly shallower depth, although this feature is poorly resolved by the TAMT data, especially with respect to lateral location.

These inversion results would appear to agree with what is known about the local geologic setting in the Shea Creek area in a more regional sense; i.e., that the conductivity anomaly corresponds in general to shallow westerly dipping sequences of graphitic-rich Archean strata.

A 1 km wide conductive zone located in the shallower part of the inverted section may reflect sandstone alteration centred around the strong conductor at 25W. A large tipper anomaly is seen at shallow depths in the vicinity of station 21W. This may be attributed to shallow faulting in the sandstone and/or the response to the lateral contact observed there.

It is interesting to note that the dominant response on the DC resistivity data is coincident with the "poor" conductor at 7W. This apparently represents an alteration feature within the sandstone since this survey was designed to profile at depths less than approximately 300 m.

Gravity surveys carried out on WAS-4 indicate that a wide (800 to 1000 m) zone of low-density material of up to -1.8 mgal is associated with the weaker eastern conductor and the zone of low resistivity centred near station 7W.

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Basement Lithologic Framework and Structural Features of the Western Athabasca Basin

C.D. Card, J.E. Campbell, and W.L. Slimmon

Card, C.D., Campbell, J.E., and Slimmon, W.L. (2003): Basement lithologic framework and structural features of the western Athabasca Basin; *in* Summary of Investigations 2003, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper D-3.

Abstract

The final phase of field work of the Western Athabasca Basement Project included core logging in the Hook Lake and Carswell areas. The Careen Lake Group supracrustal package at Hook Lake is dominated by psammites and quartzites with subordinate psammopelites and migmatitic to diatexitic pelites. It is not known whether rare mafic rocks are part of, or intrude, the Careen Lake Group. All these are cut by peraluminous granites. In contrast, the Careen Lake Group in the Carswell Structure is dominated by psammopelites and migmatitic to diatexitic pelites, with subordinate psammites and quartzites. It is intruded by granodiorites to quartz diorites believed to be related to the ca. 1.986 to 1.960 Ga calc-alkaline intrusions of the Taltson Magmatic Zone and younger granites.

The Careen Lake Group has been metamorphosed under upper amphibolite to granulite facies conditions and folded at least twice. On the other hand, the later granodiorites and quartz diorites appear to be more weakly deformed and less metamorphosed than the Careen Lake Group. This may be due to differences in the rheological properties of the rocks. It is certain that all of these rocks were metamorphosed at ca. 1.94 to 1.90 Ga, an event that led to the generation of many of the younger, anatectic granites. Ductile structures formed during the Taltson-Thelon and Trans-Hudson orogenys were repeatedly reactivated by post-Trans-Hudson faulting. Near Hook Lake, a normal fault superposed on an older ductile structure created a half graben that influenced deposition of the lower Athabasca Group.

A number of findings have resulted from this project. The oldest rocks recognized are the Careen Lake Group, which may be Archean. Alternatively, ca. 2.5 Ga granitic gneisses of the Clearwater Domain may form their basement. A ca. 1.985 to 1.968 Ga intrusive suite dominated by granodiorites and quartz diorites provides a minimum age for the Careen Lake Group and is considered the equivalent of 1.986 to 1.960 Ga intrusive rocks in the Taltson Magmatic Zone. These rocks were subjected to 1.94 to 1.90 Ga high-grade metamorphism during which a suite of dominantly peraluminous granites was emplaced. Trans-Hudson granites are also present in the region but have so far only been identified near the Snowbird Tectonic Zone and in the Clearwater Domain, indicating that their emplacement was structurally controlled.

Older ductile structures such as the Snowbird Tectonic Zone have been repeatedly reactivated. Preliminary analysis of Landsat and Shuttle Radar Topography Mission digital elevation models suggests that most of the structures that cut the Athabasca Group and ultimately played a role in the formation of present-day landforms are likely related to two major regional fault systems, the Snowbird Tectonic Zone and the Tabbernor Fault system. This analysis also allows some time constraints to be placed on the age of regional fault reactivation, including displacement that occurred after formation of the Ordovician Carswell Structure.

Discovery of a New Sandstone-hosted Uranium Mineralized Zone: Caribou Lake (McClean Lake Project, Northern Saskatchewan)

P. Portella [1] and G. Breton [1]

Abstract

The McClean Lake Project is located 400 km north of La Ronge, in northern Saskatchewan and lies along the eastern margin of the Athabasca Basin. Access to the property area is by all-weather gravel road (Highways 102 and 905) from La Ronge or Points North Landing, located 35 km to the west.

The Project is a joint venture between COGEMA Resources Inc. (70.0%), DENISON Energy Inc. (22.5%), and OURD (Canada) Limited (7.5%). COGEMA Resources Inc. is the mining and exploration operator. Work has been conducted on the property since 1974 under various partnerships (Canadian Occidental Petroleum Ltd., Minatco Limited) leading to the discovery of several unconformity-related uranium deposits (1978-1982: Jeb, McClean North and South and 1988-1991: Sue A, B, C, and E). Two of these orebodies have already been mined as open pits: the Jeb deposit, between 1995 and 1997, which was hosted in the Athabasca Group sandstone; and the Sue C deposit, between 1997 and 2002, which was found directly below the unconformity associated with basement graphitic lithologies. Recent exploration activities by COGEMA have outlined a new mineralized zone in the sandstone at the northeast end of Caribou Lake, approximately 2 km from the Sue C exploitation.

The Caribou Lake zone was discovered in March 2002 during a reconnaissance drilling program designed to further evaluate the geology and potential of the Sue Nose Trend. The area labeled as "Sue Nose" extends over approximately 1.5 km in a N70° direction, in between the northeast-southwest-trending Moffatt Lake Fault to the west and the north-south Sue Trend to the east/southeast. The Sue Nose Trend is interpreted as the folded extension of the Sue Trend lithologies, host to several of the unconformity-related deposits of the property. Preliminary compilation studies confirmed the potential of the Sue Nose area where, despite of a limited amount of exploration work, anomalous geochemical values were identified locally in the sandstone and in the basement, in the vicinity of favorable graphitic lithologies.

Very little geophysical response was found associated to the Sue Nose trend from previous surveys. Several inclined holes were first drilled to better understand the geology and the distribution of the basement graphitic units across the Sue Nose Trend. This work outlined there, in the basement, a similar lithological assemblage to the one recognized further south along the main Sue Trend. It also identified several thick conductive horizons within 100 m from a metasediment/Archean granite contact. Follow up work on the most westerly inclined hole (S690), drilled in 2002, quickly lead to the discovery of high-grade uranium mineralization in the sandstone at or near the unconformity. A delineation drilling program was conducted in 2003 over the area known as "Caribou Lake" to evaluate the extent and geometry of this new zone.

Additional high-grade mineralization was recognized during the 2003 program, mostly concentrated in the lower part of the sandstone, 100 to 125 m below surface. Among the best intersections recorded from the down hole probing data was 8.7 m of 12.99% U, 14.1 m of 10.10% U, and 4.0 m of 15.02% U. The best mineralization appears as massive to semi-massive pitchblende and is often associated to nickel-arsenides. A north-northeast-trending structural corridor controls the geometry of the ore zone. The bulk of the mineralization is located at the intersection with an east-west graphitic fault. Both trends display reverse movement. Hosting sandstone lithologies are characterized by strong alteration (illite-chlorite) and fracturing patterns. Basement assemblages are represented by graphitic metapelite, metapelite, semi-metapelite, metaquartzite, and various intrusions of pegmatite and other granite. Geochemical analyses were conducted on the mineralized intervals and will be used for a resource estimate.

Exploration activities will continue in 2004 in the Caribou Lake area. Reconnaissance work has shown that the region offers a good potential for other similar sandstone-hosted open pit targets as well as for deeper basement-hosted mineralization.

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Athabasca Uranium Exploration in the Junior Sector: UEX Corporation

Roger Lemaitre [1]

Abstract

In 2001, Pioneer Metals Corporation and Cameco Corporation teamed up form a new junior mining company, UEX Corporation, to explore for uranium deposits in the Athabasca Basin of northern Saskatchewan. UEX Corporation acquired two key assets from its founding companies. Pioneer Metals contributed its Riou Lake uranium project into the new company, while Cameco Corporation rolled the Hidden Bay Property (formerly part of the Rabbit Lake Property) into the venture.

Upon its formation, UEX Corporation controlled approximately 112 500 hectares of land in the Athabasca Basin, the world's most prolific uranium-producing region. The company is based in Vancouver, and obtained a listing on the Toronto Stock Exchange in July 2002. The company's two largest shareholders are Cameco Corporation (31.6%) and Steve Sorenson, President and CEO (9.4%).

The UEX land position in the basin is divided into two principal properties, the Riou Lake Project near Stony Rapids, and the Hidden Bay Property, immediately adjacent to Cameco's Rabbit Lake Mine and COGEMA's McClean Lake Operation. The UEX properties represent a balance between early stage grassroots properties that have the potential for the discovery of giant, world-class unconformity-type uranium deposits (Riou Lake Project), and a more mature exploration project with drill-defined resources in close proximity to existing infrastructure (Hidden Bay Property).

The 57 000 hectare Riou Lake Project is comprised of three contiguous properties, Riou Lake (100% UEX), Black Lake (UEX 50%, Cogema 50%), and Serendipity lakes (UEX earning 60% interest). The Riou Lake project is underlain by 250 to 800 m of Proterozoic sandstone of the Athabasca Group that dips shallowly to the south. The sandstone unconformably overlies Archean-aged basement rocks of the Tantato Domain. Several radiometric springs, geochemical anomalies, and a uraniferous boulder train have been identified on the project. A mere 38 diamond drill holes have been drilled on the project, some of which have identified hydrothermal alteration and weak uranium mineralization. Several exploration targets based on alteration, electromagnetic, or structural features have been identified and proposed for drilling in 2004.

The 55 498 hectare Hidden Bay Property is underlain by up to 150 m of Athabasca Group sandstone and is comprised of 38 claims located in two blocks in the eastern Athabasca Basin, immediately adjacent to two producing operations. Despite the long exploration history that dates back to the early 1970s, the property remains highly prospective for the discovery of additional uranium deposits. Several areas have been identified and proposed for drilling programs.

The previous operators of the Hidden Bay Property had tailored their exploration programs towards the discovery of traditional unconformity-type uranium deposits. The potential of the property for basement-hosted uranium deposits of the Rabbit Lake, Eagle Point, or Sue 'E' style has been essentially untested, and is the focus of the majority of UEX's present exploration efforts. Exploration proposed for the winter of 2004 on the property will test four of the many highly prospective targets identified on the property.

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Sequence Stratigraphy of the Western Athabasca Basin, Saskatchewan and Alberta

Brent Collier [1] *and Gary Yeo*

Abstract

Seven rhythmic, typically upward-fining, basin-filling third-order sequences (units bounded by unconformities or correlative conformities) are distinguished in the late Paleoproterozoic Athabasca Group in southwestern Athabasca Basin. These predominantly fluvial sequences include: the Fair Point, Shea Creek, Lower Manitou Falls, Upper Manitou Falls, Lazenby Lake, Wolverine Point, and Locker Lake–Carswell. Three ranks of sequence boundaries are distinguished in the Athabasca Group. The basal non-conformity is a first-order sequence boundary, marked by extensive regolith development and erosion of crystalline basement over an extended time. This boundary underlies other late Paleoproterozoic basins on the North American Craton. A major erosion surface with localized paleosol development at the top of the Fair Point sequence represents a depositional basin-scale second-order sequence boundary. The only third-order sequence boundary marked by an unconformity, indicated by a thin erosive basal lag conglomerate and pebbly horizons, underlies the Lazenby Lake sequence. Other third-order sequence boundaries are conformities at the base of upward-fining successions up to several hundred metres thick. Their correlative, basin-margin unconformities are not preserved.

The second-order sequence boundary above the Fair Point supports the interpretation that it is a remnant of an older basin, with a different polarity and tectonic regime than that in which the overlying Athabasca Group was deposited. Early deposits of the younger basin are best developed in a northeast-trending basement low south of the Carswell Structure called the Beatty Trough. There, the Shea Creek, Lower Manitou Falls, and Upper Manitou Falls sequences are thickest. These three entirely fluvial sequences successively thicken, coarsen, and become more extensive up-section, and collectively comprise a "Lowstand Systems Tract". The overlying Lazenby Lake, Wolverine Point and Locker Lake–Carswell sequences successively thicken, fine, and represent more diverse sedimentary environments up-section, ranging from entirely fluvial, to fluvial/lacustrine, to fluvial/lacustrine/marine(?). These collectively comprise a "Transgressive Systems Tract". The Manitou Falls/Lazenby Lake boundary marks a Maximum Regression Surface that may account for its more consistent identification in drill core. The laterally continuous pebbly layer above the boundary reflects renewed source area uplift as well as reworking of older strata during a major, probably tectonically controlled, reorganization of the basin.

The sequences distinguished here correspond well to the empirical stratigraphic subdivisions recognized by industry geologists in southwestern Athabasca Basin.

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Session 2: Trans-Hudson Orogen – Framework Studies and Metallogeny

Crustal Assembly of the Northern Reindeer Zone: Implication for Mineral Exploration in Saskatchewan and Manitoba

David Corrigan [1], Ralf O. Maxeiner, and Chris Beaumont-Smith [2]

Abstract

Over the past few years, bedrock geological mapping integrated with targeted U-Pb geochronology, Nd tracer isotope studies, lithogeochemical analysis, and LITHOPROBE seismic surveys has led to an improved geoscience knowledge base for the northern flank of the Trans-Hudson Orogen internides (northern Reindeer Zone). The current data set provides new details on the geological evolution of the La Ronge–Lynn Lake–Rusty Lake belts and further constrains orogen-parallel correlations. Key highlights include the following:

1) *The La Ronge–Lynn Lake–Rusty Lake Belts (LLR) were likely part of a continuous arc that formed and evolved during the interval 1.92 and 1.88 Ga, before being accreted to the Archean Hearne margin.*
2) *The arc plutonic root is favorably represented in the Southern Indian and Rottenstone Domains, where LLR supracrustal screens are nonetheless locally preserved.*
3) *A forearc(?) basin extends along the entire length of the LLR belt, along its northern flank.*
4) *At the Burntwood–Sickle interface, a supracrustal sequence that includes MORB-type basaltic flows and sills, ultramafic rocks, and potential exhalites is continuously exposed from near the town of La Ronge to north of Thompson, a distance of over 400 km.*
5) *A crustal segment of Sask Craton-like affinity, the full extent of which has yet to be determined, underlies the eastern Southern Indian Domain. The above provide a broad lithotectonic context for the types of mineral deposits that occur, or could permissively occur, in the greater Lynn Lake area.*

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Geology and Extent of the Archean Swan River Complex in the Patterson Island area (part of NTS 64E-10), Peter Lake Domain, Northern Saskatchewan

Ralf O. Maxeiner and Shawna M. Leatherdale [1]

Maxeiner, R.O. and Leatherdale, S.M. (2003): Geology and extent of the Archean Swan River Complex in the Patterson Island area (part of NTS 64E-10), Peter Lake Domain, northern Saskatchewan; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-6.

Abstract

A geological transect at 1:20 000 scale was mapped across the southeast margin of the Peter Lake Domain along the west shore of Reindeer Lake, encompassing part of the 2.562 Ga Swan River Complex. It is less extensive than indicated by previous workers and is intruded by large masses of monzonitic to granitic rocks. The Swan River Complex intruded subordinate mafic to felsic volcanic and migmatitic sedimentary rocks that were metamorphosed at upper amphibolite facies metamorphic grade during Neoarchean times. It comprises two distinct intrusive suites: an older and more deformed and recrystallized gabbroic suite and a younger leucogabbroic suite. These are correlated respectively with the Warner Lake gabbroic suite and the Love Lake leucogabbroic suite in the southwestern part of the Peter Lake Domain. Both have well-preserved primary igneous features common in other layered intrusions, including modal rhythmic layering, cross-bedded layering, colliform layering and layered autoliths. The Lueaza River granitoid, which is closely associated and similar in age to the Warner Lake gabbroic suite of the Swan River Complex, is characterized by foliated megacrystic monzogranite and dioritic to granitic orthogneisses. The Patterson Island Pluton forms part of a larger and more extensive monzonitic-syenitic suite, which intruded the Swan River Complex and is here tentatively correlated with the 2.54 Ga monzonitic intrusion in the Peter Lake area. The pluton consists of an outer megacrystic monzonite phase and an inner megacrystic syenite phase. Both phases have primary igneous layering preserved and grade locally into minor gabbro and leucogabbro. Massive to weakly foliated syenogranite to alkali feldspar granite of unknown age intruded most of the previous lithologies. Some of the granitoid rocks may be Archean; others may be related to the 1.86 Ga Wathaman Batholith, which underlies the southeastern portion of the transect. Two new sulphide occurrences were discovered near the 'Ant' Cu-Ni-Pt-Pd showing.

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Quaternary Investigations in the Patterson Island Area (part of NTS 64E-10 and -15), Reindeer Lake, Eastern Peter Lake Domain

J.E. Campbell

Campbell, J.E. (2003): Quaternary investigations in the Patterson Island area (part of NTS 64E-10 and -15), Reindeer Lake, eastern Peter Lake Domain; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-7.

Abstract

Quaternary geological investigations were initiated in the Patterson Island area, Reindeer Lake (part of 64E-10 and -15), as part of the multidisciplinary, multi-year Peter Lake Domain Project. The Quaternary component of the project involves surficial mapping at 1:50 000 scale, recording ice flow indicators, and regional till sampling surveys.

Multiple ice-flow directions were documented. The dominant ice-flow direction was to the south-southwest (205° to 210°), becoming more southwesterly (215° to 220°) towards the southern boundary of the map area. Two older regional ice flows were also recorded: a more southerly (~190°) direction and a west-southwesterly (228° to 240°) one. Rare, faint striae sets trending 154°/332° (two sets) and 295°/115° (one set) were also recorded.

Drift cover in the Patterson Lake area is variable. In the northern two thirds, the terrain is dominated by bedrock (approximately 40 to 50 percent) mantled with a thin (less than 2 m), discontinuous drift cover. Thus, the present day landscape is controlled by the bedrock topography with little geomorphic expression of the glacial deposits. Southward, the drift thickens and is more extensive, with bedrock exposure less than 10 percent. There, the landscape is more subdued and reflects both glacial geomorphic features and bedrock topography

The dominant surficial sediments in the Patterson Island area are till and organic deposits. Sand and gravel deposits are associated with esker systems, minor meltwater drainage channels, stagnant ice hummocky moraines, and glaciolacustrine littoral deposits. Minor glaciolacustrine silts and sands are not sufficiently extensive to differentiate at the scale of mapping. Till occurs primarily as ground moraine veneer (less than 2 m thick) and plain (greater than 2 m thick), hummocky moraine and stagnant ice moraine. Ridged moraine and streamlined forms such as drumlins and crag and tails are less common. Till composition varies with the type of deposit, thickness and source rocks from which it was derived. At least three facies were identified: a silty-sand to sandy till, sandy till, and a gravely sand diamicton.

Sporadic lacustrine deposits and raised strandlines, such as sand and cobble beaches, terraces, and wave-cut notches indicate that Glacial Reindeer Lake and glacial Lake Agassiz extended further north and west than originally thought. Much of the area below ~350 m above sea level is characterised by exposed outcrop, boulder lags, and winnowed till.

A large part of the northern half of the area is not very suitable for drift prospecting, as bedrock, ice marginal and wave-reworked deposits dominate the terrain. Drift prospecting techniques are more applicable in the south where the drift cover is more extensive. Interpretation of pending till compositional data will help determine the effectiveness of till sampling in this region.

Preliminary Investigation of the Thermotectonic History of the Central Rottenstone Domain, Hickson and Rottenstone Lakes, Saskatchewan

Kate MacLachlan

MacLachlan, K. (2003): Preliminary investigation of the thermotectonic history of the central Rottenstone Domain, Hickson and Rottenstone lakes, Saskatchewan; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-5.

Abstract

This paper reports results of 1:20 000 scale bedrock mapping in two areas in the central Rottenstone Domain of northern Saskatchewan. In the Hickson Lake area, on the eastern edge of the Rottenstone Domain, two distinct packages of metamorphosed supracrustal rocks were recognized on the east side of Hickson Lake. The first consists of massive to thinly bedded psammitic to pelitic rocks and the second includes psammitic to pelitic rocks, quartz arenites and calc-silicate rocks, as well as minor amphibolite and large metagabbro dykes. These rocks were metamorphosed to lower to middle amphibolite facies grade during an early phase of deformation that produced a bedding-parallel foliation (S_1). The second phase of deformation occurred under similar metamorphic conditions and involved tight to isoclinal upright folding of bedding and S_1. These F_2 folds are doubly plunging and have steeply east-southeast-dipping axial planes. Foliated and metamorphosed tremolite/actinolite-biotite ultramafic dykes post-date S_1, but are folded by F_2 folds. Biotite granodiorite and monzogranite of the Hickson Lake pluton intruded the supracrustal rocks and post-dated F_2 folds. Abundant granitic to syenitic pegmatite was intruded throughout the area after D_2. Migmatitic tonalite on the west side of Hickson Lake is separated from the supracrustal rocks by the Hickson Lake pluton. Folding of the main fabric in this tonalite migmatite is thought to post-date folding in the supracrustal rocks and is thus designated F_3. The final phase of folding (F_4) was only documented in the supracrustal rocks and is characterized by asymmetric folds and two conjugate crenulation cleavages with steeply dipping, east-southeast-and north-northeast-striking orientations, and post-dated pegmatite intrusion.

The second map area, around Rottenstone Lake in the central Rottenstone Domain, comprises rocks of the 'tonalite-migmatite complex'. There are five units that contain a large proportion (>50%) of well-preserved supracrustal rocks and early granitoid sheets. A strong foliation oriented parallel to compositional layering in the metasedimentary rocks and the early granitoid sheets is designated S_{main}. The supracrustal rocks include pelitic to psammopelitic migmatites with in situ leucosome, biotite-hornblende-plagioclase melanocratic metasedimentary/metavolcanic rocks, quartzite, calc-silicate, biotite psammite, and amphibolite. Granitoid sheets that pre-date S_{main} are predominantly biotite ± hornblende granodiorite to monzogranite, but also include hornblende diorite, tonalite, and quartz monzonite. A large part of the mapped area is underlain by white to pink tonalite to monzogranite that is massive to weakly foliated, contains abundant metasedimentary xenoliths and schlieren, and post dates S_{main} in the supracrustal rocks. The S_{main} foliation is folded into tight to isoclinal, upright to recumbent, doubly plunging folds with northeast-striking axial planes. These folds have been refolded by upright, open, shallowly doubly plunging folds, also with northeast-striking axial planes. The map pattern indicates that although the late granitoids post-date the main fabric, they have been affected by both later phases of folding. Ultramafic intrusions that host the Rottenstone Deposit and the Tremblay-Olsen showing occur within metasedimentary rocks and in gently plunging hinge zones of the late, upright, open folds.

The relative and absolute timing of deformation and metamorphism in the two map areas is uncertain, but is being tested with U/Pb geochronology.

The Flin Flon VMS Deposits: Challenges for Future Deep Exploration

Harold Gibson [1], Kelly Gilmore [2], Alan Bailes [3], and K. MacLachlan

Abstract

Hudson Bay Mining and Smelting's Flin Flon, Callinan, and 777 volcanogenic massive sulphide (VMS) deposits occur within the 1.9 to 1.84 Ga Paleoproterozoic Flin Flon Volcanic belt within the juvenile Reindeer Zone of the Tran-Hudson Orogen. The three VMS deposits occur at the same time-stratigraphic interval, collectively total some 86 Mt ore grading 2.49 g/t gold, 2.49% copper, 4.27% zinc, and are hosted by FIII rhyolitic flow domes and associated volcaniclastic rocks of the Millrock member of the newly defined Flin Flon Formation. The original Flin Flon deposit was discovered by prospecting in 1915 and subsequent discoveries within the belt have resulted predominately from geophysical surveys and geological mapping. With the most recent discovery, the 777 deposit, located some 900 m below surface and the upper 200 m of the main Flin Flon camp extensively explored with electromagnetic and magnetic surveys, future discoveries will undoubtedly be deep, below the detection capabilities of most existing geophysical equipment. Thus, successful exploration will require more sophisticated 3-D models of the Flin Flon VMS ore environments, volcanic/structural control on the location of the known deposits, and a more in-depth understanding of the volcanology and structure of the main camp in order to develop geological and geochemical criteria to target areas with the potential to host blind deposits.

The recently completed Geological Survey of Canada Targeted Geoscience Initiative, undertaken in partnership with the Manitoba and Saskatchewan geological surveys and Laurentian University and assisted by the mining industry, was directed at these problems. This initiative provided new and useful information regarding the origin, emplacement and environment of deposition of volcaniclastic rocks that host the VMS mineralization, structural/stratigraphic controls on their location, and geochemical criteria to detect alteration zones in the hanging wall Hidden Formation basalts. This research was a significant step forward in our understanding of the Flin Flon camp but more research needs to be done to follow-up, quantify and expand on these results, plus extend our research into existing and former mines.

To this aim, Hudson Bay Mining and Smelting, in collaboration with the Saskatchewan and Manitoba geological surveys and Laurentian University, will undertake a four-year research project in the Flin Flon Camp starting in January of 2004. The project will address specific problems including: 1) development of geological and geochemical criteria to target blind VMS deposits below the Hidden Formation; 2) completion of the reconstruction of the Flin Flon subsidence structure, which hosts the known deposits, to aid in the selection of new target areas; 3) reconstruction of the volcanic and hydrothermal history of the Flin Flon–Callinan–777ore system in order to determine structural, stratigraphic, volcanological, and geochemical (alteration) exploration criteria; and 4) establishment of the structural and stratigraphic relationship between the Myo Rhyolite and the Flin Flon Formation as this will have implications for the VMS potential in areas outside of the main camp. An equally important aspect of the research project is the training of graduate students and geoscience professionals through interaction between mine, exploration, and government and university researchers through yearly workshops.

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Session 3: Western Churchill Metallogeny

Phelps Lake Project: Geology of the Misaw Lake Area (part of 64M-NE) and Compilation Mapping in the South Half of the Phelps Lake Sheet

C.T. Harper, D. Savage, and K. Bailey

Harper, C.T., Savage, D., and Bailey, K. (2003): Phelps Lake Project: Geology of the Misaw Lake area (part of 64M-NE) and compilation mapping in the south half of the Phelps Lake Sheet; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-4.

Abstract

In 2003, 1:100 000 scale bedrock mapping was completed in the Misaw Lake area of the northeast quarter of the Phelps Lake map sheet (NTS 64M). This work identified the continuation of tonalitic and granitic migmatite complexes, that may represent basement to smaller belts of amphibolitic gneisses (mafic metavolcanic rocks) believed to be equivalent to the Archean Ennadai Group (ca. 2.71 to 2.68 Ga). Gneissic tonalite and granite, which intruded the migmatites and amphibolite gneiss, are interpreted to be late Archean (ca. 2.6 Ga). These granitic rocks underlie most of the area surrounding Misaw Lake and form the core of numerous prominent hills north and east of Misaw Lake which represent crag and tail glacial features. Although outcrops of Paleoproterozoic Hurwitz Group metasedimentary rocks were not found, the presence of abundant angular boulders of pelitic schist on the northwest flank of a granite hill, east of Goyer Lake, suggests that a bedrock source may exist in the low-lying ground north of the hill. Important aspects of the Quaternary geology include documenting at least four directions of ice flow movement, several glaciofluvial deltas associated with esker complexes, and recognition of glaciolacustrine-related raised beaches at different elevations across the region.

Mapping in selected parts of the southern half of the Phelps Lake map sheet previously mapped by others, was carried out to facilitate completion of a new 1:250 000 scale bedrock compilation map for 64M. This also offered a chance to examine some of the Wollaston Domain supracrustal rocks for possible correlation with the Hurwitz Group; however, no definitive correlations were evident.

Mineral occurrences noted in the Misaw Lake area include: i) numerous boulders and several outcrops of banded sulphide facies and oxide facies iron formations and massive sulphide (pyrrhotite, pyrite, chalcopyrite) in Ennadai Group amphibolitic gneisses; ii) disseminations of pyrite, pyrrhotite, and chalcopyrite in Ennadai Group amphibolitic gneisses; iii) structurally controlled pyritic quartz veins in Ennadai Group amphibolitic gneisses; iv) allanite ± molybdenite-bearing granitic and tonalitic migmatite boulders; and v) asbestos-like fibers in serpentinized ultramafic intrusion erratics. Examples of i) to iii) were also found in the south half of 64M.

Geology of the LeBlanc-Wellington Lakes Area, Eastern Zemlak Domain, Rae Province (Uranium City Project)

K.E. Ashton and R.C. Hunter [1]

Ashton, K.E. and Hunter, R.C. (2003): Geology of the LeBlanc-Wellington lakes area, eastern Zemlak Domain, Rae Province (Uranium City Project); *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-1.

Abstract

The LeBlanc-Wellington lakes area of the eastern Zemlak Domain is dominated by upper amphibolite facies leucogranites, gneissic to migmatitic granitoids, and massive anatectic granites derived from these sources and from subordinate supracrustal rocks of the Murmac Bay Group. Coarse-grained granites of the ca. 2.3 Ga regional suite and pink leucogranite inferred elsewhere to have been emplaced at 1.9 Ga are both represented, and at least some of the remaining granitoid rocks are considered part of the ca. 3.0 Ga basement to the Murmac Bay Group. All of these rocks underwent three initial phases of deformation (D1 to D3), the last of which was responsible for the regional northeast-trending structural fabric that is thought to have formed during a ca. 1.9 Ga metamorphic event attributed to the Thelon-Taltson Orogeny. During the uplift following this thermotectonic culmination, widespread brittle-ductile mylonitization was particularly intense in the western map area. The post-1.9 Ga exhumation was followed by deposition of the siliciclastic Thluicho Lake Group which, together with the basement rocks, was subjected to two more phases of deformation (D4 and D5) under greenschist facies metamorphic conditions prior to ca. 1.82 Ga deposition and subsequent folding (D6) of the Martin Group.

Cu-Pb-Ag vein mineralization occurs in late fracture zones best developed in mylonitic granitoids at or near the basal Thluicho Lake Group unconformity. East-trending ca. 1.82 Ga diabase dykes at several showings may have locally provided chemical traps for the mineralizing fluids, but are not considered the metal source.

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Recent Exploration and Development of the Goldfields Project, Including the Results of a GIS Study from the Recent Dighem Multi-sensor Airborne Survey

Terence J. Bottrill [1]

Abstract

GLR Resources, and the companies which are now incorporated into GLR, have been exploring the Goldfields area on the north shore of Lake Athabasca since 1987 when they first examined a high-grade platinum group metal occurrence. Recognizing the unrealized potential of the Box and Athona gold deposits they began an intensive exploration programme of drilling and bulk sampling which culminated in a feasibility study in 1995. The circumstances of the depressed metal markets ever since, especially for gold, as well as that of the mining finance market, have prevented the project from moving forward. With the turn-around in both these markets this year, GLR is moving forward rapidly to putting the mines into production as soon as feasible, using what we hope will be a more practicable approach than that proposed in 1995.

The Box mine was discovered in the 1930s and placed into production as an underground mine, mill and cyanidation plant by Cominco in 1939 until the circumstances of WWII forced its closure in 1942; since then it has sat idle. The nearby Athona deposit was explored by other companies at the same time, but never placed into production. Developed on two inclined shafts and three levels to a vertical depth of 105 m along 800 m of strike, the Box mine produced 1 250 000 tonnes. This came from four large stopes developed down the dip of 42° for over 65 m and across the full true width of up to 40 m, in what was one of the earliest examples of bulk underground mining.

Since 1987, GLR Resources has completed 201 diamond core holes totalling 31 600 m for 8,500 samples of an average of one metre long, as well as 47 reverse circulation holes for 3168 m used for bulk assays. A bulk sample of 9000 tonnes was mined from surface trenches and processed on site through a sampling tower. The products were leached on site in a pilot plant and shipped to Ontario for alternative metallurgical tests. Total reserves determined in the 1995 feasibility study are 17.3 million tonnes of 1.9 g/t Au at a cut-off of 0.67 g/t Au in the proven and probable categories. Current plans are to develop an open pit mine with gold recovery through rough gravity concentration and high intensity cyanide leaching of the concentrate to produce gold by electrotwinning. Only the concentrate will be leached with cyanide, so that at least 95% of the tails will be free of any cyanide or acid-generating sulphides, making the procedure one of the cleanest and most sustainable in Canada.

The shape of the deposit is very simple as an almost linear sheet of constant dip within the Murmac Bay Group schist and gneiss. The ore body has been described as either a granite or arkose, but is in fact an albitite of albite feldspar and variable, but lesser, quartz. Compared with the enclosing foliated gneisses it is strongly equigranular and homogeneous. It forms a series of overlapping, right-stepping structural lozenges bounded by mylonite zones. Original 5 to 10 m thick lenses were compressed into the present 40 m thick body. These equigranular albitite lenses contain numerous, narrow quartz veins which host both native gold and 2 to 3% gold bearing sulphides (each containing about 50% of the gold), mostly of pyrite with very minor galena, sphalerite, and chalcopyrite.

Very distinct layering is apparent in the enclosing wall rocks in the entire Goldfields area which appears to be folded around a northeast-striking axis, with the Box and Athona deposits on the opposite limb of the fold.

The results of the 1997 Dighem airborne survey of magnetics, electromagnetics, and radiometrics have been reprocessed and geo-referenced with the LANDSAT imagery and the recent geological mapping by the Saskatchewan Geological Survey. Used in a geographic information system (GIS), the combined data sets provide a very detailed background geological model for the entire district.

Apart from the gold deposits such as Box-Athona, and the past-producing uranium deposits, numerous other types of mineralization, including base metals and platinum group elements, characterize the entire Goldfields–Beaverlodge–Uranium City district. Each of the major deposits are enclosed in areas of distinct geophysical characteristics, probably due to extensive alteration, such as seen in the radiometric highs around the Box-Athona area which clearly outline the apparent open fold in the area. The magnetic data clearly outline distinct domains

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within the Murmac Bay Group, as well as the contact with the unconformable middle Proterozoic Martin Group red-bed, clastic sedimentary rocks.

Several discrete, high-amplitude, magnetic anomalies can be differentiated from the variable background, none of are easily explained by the surface mapping. Several of these are close to the Martin Group unconformity, such as beneath the waters of Beaverlodge Lake, or associated with the immediately adjacent Murmac Bay Group along the lakeshore where the bedrock contains abundant pervasive haematite. Many of these metallogenic features are consistent with Iron Oxide-Copper-Gold (IOCG) deposits developed in similar sedimentary sequences deposited in ensialic grabens, the depositional environment proposed for the Murmac Bay Group, especially where they lie beneath unconformable Proterozoic red-bed sequences. Together with the known surface showings, the recent airborne survey as processed by GIS has highlighted numerous targets which should keep the future exploration department at the Box-Athona mine busy for many years to come.

The Western Churchill Metallogeny Project: Towards a Modern Synthesis Without Borders

S.J. Pehrsson [1] and the Western Churchill Metallogeny Project Team

Abstract

The Western Churchill Metallogeny project is a three-year, multidisciplinary and multi-agency initiative to understand the nature, distribution, and context of mineral resources in the Western Churchill Province (WCP). One of the largest geologic provinces of the Canadian Shield, spanning Nunavut, the Northwest Territories (NWT), northern Saskatchewan, Manitoba, and northeast Alberta, the WCP has huge untapped mineral potential and is presently the site of active exploration for gold, diamonds, Ni-Cu-PGEs, and uranium.

The WCP includes at least four distinct lithotectonic domains that have distinct tectonic histories that affected their regional metallotects. Each of these domains straddles the five provincial and territorial borders. Recent major geoscience initiatives within the WCP have been focused in northern Saskatchewan (SIR) and central Nunavut (Western Churchill NATMAP, TGI-2). These areas have the best modern data sets pertaining to the nature of the province, but are separated by large tracts in southern NWT, Nunavut, and northern Manitoba with poor or very dated understanding. The next quantum leaps in understanding the tectonic history of the WCP and the context of its mineral resources will come from bridging the gaps in these areas and carrying exploration strategies, metallotects, orogenic structures, etc. across from one end of the WCP to the other. Many of the critical questions to be addressed are still fundamental: the extent and nature of Archean versus Proterozoic crust; the regional extent of 2.5 Ga, 2.3 Ga, and 1.9 Ga tectonometamorphic and magmatic events; and the distribution and degree of ca. 1.85 to 1.8 Ga Paleoproterozoic orogenic reworking. All of these influenced the localization and distribution of mineral deposits.

An initial phase of the project will centre on compilation and synthesis of the metallogeny and geology of the central and northwestern Hearne domain of Nunavut, focus of the recent Western Churchill NATMAP. Phase 2 will encompass the northern part of the Rae domain in Nunavut and NWT, while the third and final phase will encompass the southern Hearne and Rae of all five provinces/territories, including the Athabasca EXTECH IV area. Activities will include development and analysis of a digital mineral assessment database, compilation, and publication of new 1:250 000 and 1:1 000 000 scale bedrock and metallogeny maps, and expert and layperson mineral potential maps. Quaternary studies will produce new surficial geology, till geochemistry and regional ice flow maps, along with an integrated assessment of Quaternary history between Nunavut and northern Saskatchewan.

Emphasis will be on interim product release, including new 'remote predictive maps' based on integration of archival data in reconnaissance areas with modern geophysical data sets. Targeted acquisition of new geochronologic, tracer isotope, thermobarometric, and lithogeochemical data along a transect from Committee Bay to northern Manitoba will provide the first ever complete cross-section of the WCP and the Rae/Hearne domain boundary. Additional acquisition will be focused in the south-central part of the province at the junction between NWT, Nunavut, Saskatchewan, and Manitoba, site of ongoing and new provincial/territorial mapping initiatives.

[1] Geological Survey of Canada, Natural Resources Canada, 601 Booth Street, Ottawa, ON K1A 0E8.

Progress on the Tazin Lake Map Area (74N) for Development of a New NTS-Based Metallogeny Database Series

Michael H. Gunning

Gunning, M.H. (2003): Progress on the Tazin Lake map area (74N) for development of a new NTS-based metallogeny database series; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper B-3.

Abstract

The Saskatchewan Mineral Deposits Index (SMDI) is an expansive repository for basic information on all metallic mineral occurrences in northern Saskatchewan. This paper outlines an expansion of the SMDI. New data fields will be added to integrate provincial mineral occurrence information with current bedrock geology and regional tectonic maps, and modern mineral deposit models. Further, text fields which summarize the geology of each occurrence will be broken down into numerous keyword fields to enhance the "searchablility" of the database. Population of the new database will begin with the Tazin Lake Map Area (74 N), located in the northwest corner of the province.

The purpose for expansion of the SMDI is to produce a more powerful GIS application with greater search capacity, and facilitate stronger integration between mineral deposit data and other geoscience framework data for the Precambrian of northern Saskatchewan. A specific objective is to add fields in such a way as to link the geologic context for each SMDI occurrence to updated digital 1:250 000 geological compilation maps for northern Saskatchewan.

The expected outcome of this project is the evolution of SMDI from a digital archive of mineral deposit data to a more powerful GIS tool for district-scale metallogeny. Compiling information and populating the new database will be the basis for identifying new, field-based mineral deposit studies which will address specific, and relevant knowledge gaps in district-scale metallogeny.

Preliminary Structural Study of the Gold-bearing Shear Zone System at the Seabee Mine, Northern Saskatchewan

Ghislain Tourigny

Tourigny, G. (2003): Preliminary structural study of the gold-bearing shear zone system at the Seabee Mine, northern Saskatchewan; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper B-1.

Abstract

The Seabee gold deposit is a structurally controlled, mesothermal vein gold deposit developed in weakly deformed metagabbroic rocks of the Laonil Lake Intrusive Complex, northern Saskatchewan. The gold-bearing veins are hosted by narrow, steeply northwest-dipping to subvertical, northeast- and east-northeast-trending shear zones consisting of well-foliated L-S tectonites that are characterized by a steep mylonitic foliation and a steeply west-plunging mineral lineation. Auriferous veins occur as riedel 'R' and 'P' veins oriented 5° to 15° from the shear foliation, as fault-fill veins subparallel to the foliation, and as minor extension veins oriented at a high angle to the shear zone boundary. Coexisting strain and kinematic indicators reveal that the auriferous shear zones recorded a strong component of boundary-normal compression combined with subhorizontal dextral shear. The auriferous shear zones are either late reverse faults, reactivated as dextral strike-slip faults, or dextral transpression zones developed between converging rigid walls. Preliminary interpretation suggests that dextral transpression best explains the emplacement and deformation of the shear zones and associated gold-quartz veins.

Detailed Study of the Bingo North and Bingo South Gold Showings, Dickens Lake Area, La Ronge Volcanic Belt

Ghislain Tourigny

Tourigny, G. (2003): Detailed study of the Bingo North and Bingo South gold showings, Dickens Lake area, La Ronge Volcanic Belt; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper B-2.

Abstract

The Bingo North and Bingo South showings are part of a 300 m long brittle-ductile shear zone containing resources estimated at 81,000 ounces of gold. The mineralization occurs within the eastern margin of the Bernaski Bay granitic pluton, which intrudes the southern part of the La Ronge greenstone belt. The orientation and development of metre-scale, gold-bearing shear zones were greatly influenced by northwest-trending quartz-diorite dykes with which they are intimately associated. These small-scale shear zones exhibit evidence of a complex shearing history recorded by sinistral shear-sense indicators on horizontal surfaces and moderately to steeply northwest-plunging lineations in subvertical section. The auriferous shear zones are interpreted to be antithetic sinistral transpression zones developed during dextral transpression along the northeast-trending McLennan Lake Tectonic Zone, which juxtaposed the La Ronge Domain against the sedimentary Kisseynew Domain to the east.

Weyburn and Beyond: Hydrocarbons, Potash, Diamonds, and More

C.F. Gilboy, S. Whittaker, F.M. Haidl, L.K. Kreis, P.K. Pedersen, M. Yurkowski, and E.H. Nickel

Abstract

The total value of goods exported from Saskatchewan in 2002 was $16.7B, of which $6.4B (38%) were from the sale of oil ($4.3B), potash ($1.7B), and natural gas ($0.4B), resources that are obtained from the province's Phanerozoic sedimentary rocks. The oil, potash, and natural gas industries are also important because of the numbers of people they directly and indirectly employ and the widely distributed areas in which this employment occurs.

In an effort to understand more fully the geological conditions that control the location of economically viable hydrocarbon accumulations and potash, and therefore sustain high levels of activity through the next several decades, the province is developing long-term (ca. 2003 to 2012) plans to systematically map or remap our Phanerozoic strata from basement to near-surface. A multi-disciplinary approach is being taken, with hydrogeological and geophysical studies taking place concurrently with conventional log- and core-based mapping. Results are, and will continue to be, presented in GIS and other formats that maximize their usefulness to industry for both exploration and development purposes. This work is, as far as possible, being coordinated with that in adjacent provinces and states to ensure cross-border geological continuity.

The first major undertaking that has spear-headed this new, collaborative approach to subsurface investigations has been the Geoscience Framework component of the International Energy Agency's Weyburn CO_2 Monitoring and Storage Project, Phase 1, which started in earnest in 2002 and is due for completion in mid 2004.

This presentation looks at some of the results emanating from the Weyburn project, outlines some of the projects that are about to begin, and makes mention of other resources such as diamonds, coalbed methane, and brines that are hosted within Saskatchewan's Phanerozoic strata and that may in future be economically important to Saskatchewan.

Prospects to Production – Contributions of the Saskatchewan Mineral Industry

P.L. Schwann

Abstract

The mineral industry invested $27.8 million in grassroots exploration for metallic minerals in Saskatchewan during 2002. Exploration expenditures for 2003 are forecast to be $35.7 million. Uranium continues to be the primary target of exploration, contributing about 38% of the exploration investment; however, diamond exploration programs are forming an increasingly significant proportion of the exploration investment.

Mineral land tenure is also a barometer of the exploration climate. As of October 31, 2003, 3,419 metallic mineral dispositions covering 2.1 M ha of Crown mineral lands were in good standing. Of these, 1559 dispositions covering 1.5 M ha were located in the unsurveyed part of the province while 1,860 dispositions covering 648 000 ha were active in the surveyed area, primarily in the Fort a la Corne area. Activity in the industrial minerals sector remains relatively stable. The growth in the landscaping industry is reflected by renewed interest in quarriable materials such as dolomite. There are 938 active industrial mineral dispositions for potash, coal, sodium sulphate, and quarriable substances that cover 346 000 ha. In total there are currently 4,357 active metallic and industrial mineral dispositions totaling 2.5 M ha of Crown mineral lands.

The Mineral Exploration Incentive Programs, including the Corporation Exploration Incentive Program and the Prospectors Exploration Incentive Program are now in their second year. The program has an annual budget of $2.1 million. In the first year, 26 programs were initially approved, however, only 16 projects were completed and funded. In 2003-04, the second year of the program, 37 programs, representing $11 million in exploration investment have applied for approval. These exploration programs are diverse in both the target commodity and geographic area.

In 2003, uranium mining activities continued at McArthur River and Eagle Point, while milling of stockpiled ore from JEB and SUE C continued at the McClean Lake site. Production from Cluff Lake wound down in 2002. Primary gold production continued from the Seabee Mine, with copper, zinc, and secondary production of gold and silver from the Callinan and Konuto Mines.

Saskatchewan remains Canada's third largest, non-fuel mineral producing province. There are currently 25 mine operations across Saskatchewan that produce a diversity of minerals including, potash, uranium, coal, gold, base metals, sodium sulphate, salt, and clay. The combined value of sales for these minerals in 2002 was a record $2.6 billion dollars.

A Progress Report on the Regional Land Use Planning Process and the Representative Areas Network Program in Saskatchewan

Murray C. Rogers

Abstract

The Government of Saskatchewan is currently involved in numerous regional integrated land use planning exercises. The planning processes usually only directly involve Crown surface lands. Saskatchewan Environment (SE) initiates and leads the land use plans under their management, mainly in the north. Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR) leads the plans under their management, mainly in the south. The public advisory planning committees that develop the plans consist of representatives of community and interest groups. The mining and/or oil and gas industries are members of the committees on most of the plans. Representatives of the government departments act in advisory and resource capacities. Saskatchewan Industry and Resources (SIR) participates in the development of all of the plans.

Important considerations for industry are potential restrictions on surface access and activities that may result from these processes. These include the review of Representative Areas Network (RAN) site proposals, regional zoning on land use, buffers around water bodies, historical, cultural, archeological, and ecological sites, and the establishment of wildlife management areas. Other relevant issues that are commonly discussed include road and trail development and closure, public consultation, compensation, and environmental monitoring of activities.

Nine land use plans have been completed and are being implemented. These are the La Ronge (2003), Whitehood (2002), RM Torch River (2002), Prince Albert Model Forest (2000), Pasquia-Porcupine (1998), Fur Lakes (1998), Fowler and Murphy lakes (1997), Manitou Sand Hills (1996), and Great Sand Hills (1991).

There are currently 10 land use plans that are being developed in the province. SE-led planning processes include Amisk-Atik, Fort a la Corne Provincial Forest, Buffalo Pound Lake, North-Central, Pinehouse-Dipper, Athabasca Road Corridor, and Nisbet Provincial Forest. SAFRR led plans include Bjorkdale, Stove Creek, and Grand Cheviot.

The Government of Saskatchewan, with SE as the lead department, initiated the Representative Areas Network (RAN) program in 1996. The RAN is composed of lands and waters selected and designated to represent the natural ecological and biological diversity of the province and managed to retain that diversity. RAN sites act both as reservoirs of biological diversity and benchmarks for comparison with the more heavily used landscape. There are 11 ecoregions in the province to represent. The RAN includes the existing parks and other previously designated lands. Other government departments, including SIR, are actively involved in the RAN selection process, as well as the general public and industry.

A specific process exists for the review of the RAN site proposals by SIR and industry. SIR initially carries out technical reviews of the mineral (and oil and gas) potential of the proposed sites using qualitative mineral resource assessments that are based on compiled geoscience, mineral deposit, and exploration information. The intent is to locate the RAN sites in areas of low assessed mineral potential. Proposals that may be acceptable are forwarded for review and comment to a range of industry organizations, companies, and individuals, including any disposition holders in the region. Public review of RAN site proposals is often done through the land use plans.

Since 1997, 41 sites totaling about 665 000 hectares (ha) have been formally designated under the RAN program. The Caribou Flats (10 642 ha) and Budd Lake (17 924 ha) sites were announced in 2003. One site proposal, Ile-a-la-Crosse (3740 ha), has been reviewed and approved by SIR and industry.

A number of proposed sites, some very large, are currently at various stages of review and discussion by SE, SIR, and industry. These include Tazin Lake (NTS 74N), Chappuis-Fontaine lakes (NTS 74O), Misaw Lake (NTS 64M), Pink Lake (NTS 74A), Geikie River (NTS 74A,H), Cree Lake (NTS 74B,G), Firebag Lake (NTS 74F), Fort à la Corne (NTS 73H), Nisbet River (NTS 73G), and Nisbet Upland (NTS 73B). The public will review most of these proposals through land use planning processes. Interim 10 year surface designations, that allow mineral exploration and development, have been established by SE on the proposed Tazin Lake, Chappuis-Fontaine lakes, and Misaw Lake sites until decisions are made on any formal designations.

For more information please contact me or examine my poster display. Detailed handouts are also available at the poster.

Cooperative Geological Mapping Strategies Across Canada: Where Are We Headed?

Simon Hanmer [1]

Abstract

"Cooperative Geological Mapping Strategies Across Canada" (CGMS) was a 10 year vision statement written by the National Geological Surveys Committee (NGSC) that focused on the continuing need for reliable geoscience knowledge relating to mineral, energy and groundwater resources, compatible with the Intergovernmental Geoscience Accord. The NGSC's vision statement, approved by all of Canada's Mines Ministers in 2000, identified geoscience knowledge as a key competitive advantage, essential to maintaining Canada as a pre-eminent global destination for exploration investment, which has been put at risk by decreased levels of effort by government agencies and industry. Hence the CGMS initiative presents itself as the effective vehicle for renewed government investment in public geoscience.

In spring 2003, the Geological Survey of Canada met with each of the provincial and territorial Geological Survey organizations in order to better understand their perception of geoscience gaps and needs in their jurisdictions. These meetings highlighted the emergence of an inter-provincial/territorial mind-set with respect to CGMS that will promote cooperation across jurisdictional boundaries, facilitate priority setting at the broadly regional and national scales, and better guide the federal contribution to CGMS.

Public geoscience is a tool to address government issues and priorities, to contribute to the "Public Good". In the context of CGMS, this implies fostering the "Sustainable Development of Natural Resources", and reducing the risk related to resource exploration and development by providing decision-makers, including industry, government, and society at large, with the sound scientific basis for determining how, where and when resource development should take place. This could range from geological mapping to stimulate exploration in areas where resource potential is poorly understood, to geological mapping to enable decisions to be taken regarding the environmental impact of resource development.

CGMS is a national initiative that will require a national workshop, and inter-provincial/territorial workshops represent an appropriate and necessary stepping-stone. A pilot inter-provincial/territorial workshop with federal participation will be held in Ontario in January 2004, focusing on central Canada and the Canadian Shield followed, in principle, by other workshops that will focus on western, Atlantic and northern Canada.

If "Strategies" are indeed inter-provincial/territorial in nature, with active federal participation, access to the knowledge produced under their auspices should not be impeded by jurisdictional boundaries. The credibility of the CGMS initiative would be undermined without a delivery mechanism capable of serving the needs of the end-users. Collectively, members of the NGSC are currently developing such a delivery mechanism in the form of Canadian Geoscience Knowledge Network.

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Session 4: Saskatchewan Diamonds – Carats, Context, and Other Frontiers

Saskatchewan Kimberlite Indicator Mineral Database: New Data and Review of Selected Results

Lynn I. Kelley

Kelley, L.I. (2003): Saskatchewan Kimberlite Indicator Mineral Database: New data and review of selected results; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper C-2.

Abstract

New data from samples collected by Saskatchewan Geological Survey field parties in 2001, 2002, and 2003 have been added to the Saskatchewan Kimberlite Indicator Mineral database. This note describes the new data and highlights anomalous results from the compiled data set.

Sedimentologic and Stratigraphic Constraints on Emplacement of the Fort à la Corne Kimberlites, East-central Saskatchewan

John-Paul Zonneveld [1], David H. McNeil [1], Bruce A. Kjarsgaard [2], and Shawn E. Harvey

Abstract

Diamond-bearing kimberlites in the Fort à la Corne region, east-central Saskatchewan, consist primarily of pyroclastic deposits which are interstratified with Lower Cretaceous (Albian and Cenomanian) marine, marginal marine, and continental sediments. Approximately 70 individual kimberlite occurrences have been documented. Integration of multi-disciplinary data-sets has helped to refine and resolve models for emplacement of some of these kimberlite bodies. Detailed core logging has provided the foundation for sedimentological and volcanological studies and in constructing a regionally consistent stratigraphic and architectural framework for the study interval. Micropaleontologic and biostratigraphic analysis of selected sedimentary rocks, and U-Pb perovskite geochronology on kimberlite samples have been integrated to define periods of kimberlite emplacement.

Radiometric age determination and micropaleontologic evidence support the hypothesis that multiple kimberlite eruptive phases occurred at some of the Fort à la Corne kimberlites. The oldest kimberlites erupted during deposition of the predominantly continental strata of the lower Mannville Group (Cantuar Formation). Kimberlites within the Cantuar Formation include terrestrial airfall deposits as well as fluvially transported kimberlitic sandstone and conglomerate. Successive eruptive events occurred contemporaneous with deposition of the marginal marine upper Mannville Group (Pense Formation). Kimberlites within the Pense Formation consist primarily of terrestrial airfall deposits and associated massive kimberlite vent deposits within the underlying feeder pipe. Fine- to medium-grained cross-stratified kimberlitic (olivine dominated) sandstone in this interval reflects reworking of airfall deposits during a regional marine transgression. The youngest eruptive events occurred contemporaneous with deposition of the predominantly marine Lower Colorado Group (Joli Fou, Viking, and Westgate formations). Kimberlite beds, which occur at several horizons within these units, consist of subaerial and marine airfall deposits, the latter commonly exhibiting evidence of wave-reworking. Black shale-encased kimberlite beds, deposited as subaqueous debris flows and turbidites are particularly common in the Lower Colorado Group.

The proportion of extra-crater kimberlite and the degree to which these kimberlites were reworked varies considerably between individual Fort à la Corne kimberlites, depending on the timing and nature of individual eruptions. Several examples exhibit multi-eruptive histories. Sedimentologic, volcanologic, and stratigraphic evidence indicate that these kimberlites evolved from simple feeder vents with overlying shallow asymmetric tuff rings, into positive-relief tephra cone. In most cases the final shape of the volcanic edifice (tuff ring or tephra cone) was modified during marine transgression, resulting in wave-reworked kimberlite sand along the fringes of the cone and kimberlitic event deposits (tempestites, turbidites, debris flows) in more distal settings.

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A Biostratigraphic Transect Across the Star Kimberlite Body of East-central Saskatchewan – Preliminary Results

David H. McNeil [1], Graham Dolby [2], John-Paul Zonneveld [1], and Bruce A. Kjarsgaard [3]

Abstract

The Star Kimberlite, which occurs at the southern margin of the Fort à la Corne kimberlite field in east-central Saskatchewan, is exceptional in its preservation of feeder vent/maar deposits and pyroclastic kimberlites interstratified with terrestrial to marine sedimentary rocks of the Cantuar, Pense, Joli Fou, Viking, and Westgate formations. Shore Gold Incorporated has accumulated a comprehensive database of 15 cores from the central area of the body and another 20 cores delineating the surrounding apron deposits. A transect of six cores was delineated to establish biostratigraphic constraints on the emplacement of the Star kimberlites.

*The transect begins on the north fringe of the Star body where several pyroclastic kimberlite units occur between the Westgate Formation and the lower Cantuar Formation. Two important biostratigraphic zones bracket the kimberlite events. Above the kimberlites, the early Late Albian **Miliammina manitobensis** Zone of the Westgate Formation is clearly represented. Below the kimberlites, in the Cantuar Formation, is a newly discovered occurrence of the **Verneuilinoides cummingensis** Subzone (**G. nanushukensis** Zone) of Early Albian age, which establishes the lower limit for kimberlite pyroclastics in this area. The occurrence of this subzone is also a significant paleogeographic discovery documenting the easternmost extent of the Moosebar/Clearwater Sea, previously known only from central Alberta, northeastern British Columbia, and northwards.*

In the central area of the Star Kimberlite, two cores were sampled for microfossil analysis. The cores are situated approximately 50 m south and east of the feeder vent. Poorly fossiliferous Albian shales overlie kimberlites in both of these cores, but the limited biostratigraphic data indicates a pre-Westgate stratigraphic position equivalent to the lower Viking or the upper Joli Fou. In these cores, and nearby cores, the bulk of the kimberlites are volcaniclastic vent and pyroclastic airfall deposits with the exception of a 5 to 10 m thick kimberlitic shale interpreted as crater fill. The kimberlitic crater-fill shale contains plant fossils, fusain, and pollen and spores typical of a swamp/marsh environment, of Albian, probably pre-Late Albian age. No marine fossils have been recovered from the crater fill facies in either the micropaleontological or the palynological investigations.

To the east of the central area, three cores have been sampled, representing the eastern fringe of the Star Kimberlite where pyroclastic, subaerial to subaqueous, airfall kimberlites generally less than 20 m thick occur interbedded with strata of the Joli Fou and Viking formations. The pyroclastic kimberlites occur at several levels within the Joli Fou and Viking formations. Fish fragment marine lag deposits containing indicator minerals commonly occur above and below the kimberlites and at isolated horizons within Joli Fou and Viking sediments. The stratigraphic position of the pyroclastic kimberlites can be established biostratigraphically by correlation with the Leather River and Crooked River cores 50 km to the southeast, where 1 m sampling for microfossils has provided a detailed biostratigraphic record for local correlations.

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The Value of New Geophysical Surveys at Fort à la Corne

Bruce McMonnies [1]

Abstract

Regional magnetic and gravity data for the province of Saskatchewan do not clearly identify the kimberlites at Fort à la Corne. However, Jiri. G. Strnad using this information did make the correct interpretation leading to the discovery of the field. The Uranerz magnetic survey in 1989 further defined the Fort à la Corne kimberlite field. It is important to note that the large size and lack of depth extent of the anomalies contradicted what was known about the airborne response of kimberlites at the time. In 1990, the joint venture flew the Fort à la Corne single sensor magnetic survey to the best available parameters. This data, with ground follow-up, has been used as the basis for all geophysical interpretations until now. Ground follow-up has been costly due to the size of the grids required.

Major advances have occurred to airborne magnetic surveying over the past 15 years. Costs have been significantly reduced. Data acquisition is more accurate with higher resolution. Multiple sensors on the platform permit the acquisition of triaxial gradient data.

During 2003, the Shipman Trail survey was flown with the Goldak Tri-Max system. The aim was to cover the Joint Venture claims providing detailed base magnetic maps quickly and at a low cost to help with the mapping of 122,140/141,148 and 150 kimberlites. Ground gravity grids were also completed over these kimberlites adding a new dimension to the understanding of the rock properties and drilling of these kimberlites. All the data will now be used for joint 3-D constrained inversion modeling.

In conclusion, a tremendous amount of value has been added to the project by conducting new geophysical surveys.

[1] De Beers Canada Exploration Inc., One William Morgan Drive, Toronto, ON M4H 1N6.

Kimberlite Eruptive Sequences and Volcanic Stratigraphy of the 140/141 Kimberlite, Fort à la Corne Field, Saskatchewan

S.E. Harvey, B.A. Kjarsgaard [1], and J. -P. Zonneveld [2]

Abstract

Volcaniclastic kimberlite is typically interstratified with Lower Cretaceous continental to marine sediments of the Mannville and Lower Colorado groups in the Fort à la Corne kimberlite field of central Saskatchewan. The areal extent of the diamondiferous Fort à la Corne 140/141 kimberlite body, near the southeastern edge of the field, is approximately 250 hectares, and its estimated mass is 900 million tonnes. Integration of multidisciplinary data-sets, including detailed core logs of kimberlite and Cretaceous sedimentary rocks, kimberlite geochemistry, 2-D seismic surveys, borehole geophysics, and biostratigraphy, are being utilized to develop a 3-D model for the kimberlite.

Detailed logging of 32 cores has delineated at least eight distinct kimberlite phases. Each of these phases is characterized by a distinctive magnetic response and chemistry. Subaerial and marine airfall deposits, pyroclastic flow deposits, debris flows, and, possible base-surge deposits have been recognized in core. Possible feeder vents have been identified for five of the eight phases. These are all aligned along a northwest trend.

The oldest kimberlite phase is interstratified with siliciclastic rocks of the upper Cantuar Formation. The youngest kimberlite phase is overlain by marine shales of the Westgate Formation. This suggests that the 140/141 body represents periodic volcanism over at least 3 m.y. The kimberlitic phases include one and possibly two that are Cantuar-age equivalent, three and possibly four that are Pense-age equivalent, two that are Joli Fou-age equivalent and one that is Viking-age equivalent.

Preliminary major and trace element geochemical data indicate a strong correlation between kimberlitic phase and geochemistry. Bivariate plots of incompatible high-field strength elements such as Ta, Nb, Zr, Th, and REEs, and compatible elements such as V, Ni, and Co are robust discriminators of kimberlite phases.

A 3-D model of the 140/141 kimberlite is being developed. This could be an important framework for examining diamond grades and values.

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Seismic Images from the Fort à la Corne Kimberlite Field, Saskatchewan

D. White [1], B. Kjarsgaard [1], G. Buffet [1], B. Roberts [1], J.-P. Zonneveld [2], and S. Harvey

Abstract

In December 2002, two high-resolution seismic surveys were undertaken in the Fort à la Corne kimberlite field, central Saskatchewan. A grid of 2-D seismic lines totalling ~12 line km in length were recorded across the Fort à la Corne Joint Venture (De Beers Canada Exploration Inc. (42.25%), Kensington Resources Ltd. (42.25%), Cameco Corporation (5.5%), and UEM Inc. (carried 10%)) 140/141 kimberlite body. In the second survey, a 500 m x 500 m 3-D seismic survey was undertaken on the Shore Gold Inc. Star kimberlite body, supplemented by four 2-D profiles. A mini-Vibroseis energy source was used for all surveys with a sweep of 30 to 300 Hz and geophone groups were spaced at 3 to 5 m. Initial seismic images will be presented with preliminary interpretations based on correlation with geological/geophysical logs. Early results indicate that the top and bottom of the kimberlite is imaged with laterally continuous internal stratigraphy of the kimberlite abruptly truncated in the areas of feeder vents.

[1] Geological Survey of Canada, Natural Resources Canada, 615 Booth Street, Ottawa, ON K1A 0E9.
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What Makes a Diamond Shine: An X-ray Fluorescence and Optical Luminescence Study of Diamonds

J.N. Cutler [1] and D.H. Quirt [2]

Abstract

Diamonds have become an important mineral resource in northern Canada. With their increased profile, many issues associated with identification, characterization, and processing of the raw material are increasingly more important. These concerns are associated with the diamond's physiochemical properties which include: 1) establishment of reliable identification for the presence of diamond in a stream of heavy mineral concentrate during diamond ore processing; 2) identification of the geographical origin of diamonds (an issue for the diamond industry and international law enforcement agencies); and 3) determination of a natural or synthetic source of a diamond.

First, fluorescence identification and subsequent sorting of raw diamonds within processed ore from certain geographical regions is inefficient due to variations in luminescence/fluorescence properties of diamond. Second, legal issues associated with whether a diamond was mined in South Africa, NWT, Australia, etc., or is a "conflict" or "blood" diamond from various warring African nations are important for the pedigree of the gem. Third, for a gemologist, the distinction between a natural or synthetic diamond is an important emotional issue related to the retail sale of diamonds.

In order to understand why diamonds from different geographical areas have significantly different fluorescence yields, the bulk and surface characteristics of diamond were examined using X-ray Excited Optical Luminescence (XEOL) and Synchrotron X-Ray Fluorescence (SR-XRF). These techniques have given some tantalizing insight into the chemistry of diamonds and a relationship to their origin.

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Volcanology and Petrology of the Star Kimberlite, Saskatchewan

B.A. Kjarsgaard [1], S. Harvey, L.M. Heaman [2], J.-P. Zonneveld [3], D. McNeil [3], and J. Mwenifumbo [1]

Abstract

The diamondiferous Star kimberlite, in the southeast part of the Fort à la Corne kimberlite field, central Saskatchewan, has an estimated contained mass of more than 450 million tonnes of kimberlite. Detailed logs of 31 drill cores, containing kimberlite and Cretaceous sedimentary rocks, were integrated with data from U-Pb geochronological, biostratigraphic, kimberlite major and trace element geochemical and borehole geophysical studies to develop conceptual 2-D and 3-D models for the Star kimberlite.

Four distinct phases of kimberlite are recognized in the Star body. The oldest kimberlites are conformable subaerial pyroclastic fall deposits (and their fluvial reworked equivalents) in siliciclastic sediments of the Cantuar Formation. These Cantuar-age equivalent kimberlites occur predominantly in the north-central part of the Star kimberlite in intervals less than 10 m thick. Slightly younger kimberlite pyroclastic fall deposits conformably overlie shales of the Pense Formation over a wide area in the northern and eastern parts of the Star kimberlite. Typical drill intersections vary from 2 to 35 m thick. These kimberlites are of Pense-age equivalent. The youngest, and volumetrically most significant kimberlites, are in the western half of the Star kimberlite body. Variable, but typically thick intersections (~20 to >500 m), dominated by subaerial pyroclastic fall deposits are common. These kimberlites conformably overlie lower Joli Fou Formation sediments and are capped by sediments of the Viking and/or Westgate formations, hence they are considered Joli Fou-age equivalent. The Joli Fou-age equivalent kimberlite is subdivided into an early phase and a late phase separated by a break. This break, or hiatal surface, is typically defined by a variably developed weathered zone. U-Pb perovskite geochronology of the Star kimberlite indicates it formed over a period of 1 to 2 million years between about 104 Ma (Cantuar-age equivalent kimberlite) and 103 Ma (Joli Fou-age equivalent kimberlite). These U-Pb data are consistent with micropaleontology data from sedimentary rocks hosting the Star kimberlite.

Multivariate statistical analysis (cluster analysis, principal component analysis) of whole rock major and trace element geochemical data supports subdivision of the Star kimberlite body into four distinct kimberlite phases: Cantuar, Pense, early Joli Fou, and late Joli Fou. Of these four phases, the early Joli Fou kimberlite and the Pense kimberlite have the highest "mantle signature" as defined by MgO, Ni, Co, and Cr concentration levels. Interestingly, these two phases of kimberlite are also the most volumetrically abundant phases in the Star body. Geochemical distinction of the early Joli Fou kimberlites from late Joli Fou is straightforward as the concentration of 'incompatible' elements such as La, Ce, Th, U, Nb, Zr, P_2O_5 are much higher in the late Joli Fou kimberlites. The geochemical distinction between the early and late Joli Fou kimberlites is also apparent on downhole geophysical logs of multi-spectral and total count gamma data, for which the late Joli Fou kimberlites have higher K_2O, eTh, eU and total count signatures.

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The Star Kimberlite Bulk Sample Program

George H. Read [1]

Abstract

Shore Gold Inc. is in the process of obtaining a bulk sample from the company's Star kimberlite, located in the Fort à la Corne area of central Saskatchewan. This aggressive program is designed to recover a parcel of at least 3,000 carats of diamonds to enable an accurate valuation of the stones. The program involves the sinki ıg of a 4.5 m diameter vertical shaft and lateral drifting in kimberlite to recover up to 25 000 tonnes of kimberlite. The mining contract for this program was awarded to Thyssen Mining and Construction Ltd. ("Thyssen") of Regina, Saskatchewan.

Given the extent of the Star kimberlite, it was necessary to select a location for the sample that would allow the sample to be reasonably representative of the entire body and not just one discrete location. The location for the bulk sample was selected after a report was received from AMEC E & C Services Limited, which had reviewed the microdiamond data from all the holes completed on the Star kimberlite body. AMEC's report concluded that the Star kimberlite appeared to be relatively homogeneous and while there did appear to be the possibility that a higher grade region was present within the Star body, the selected location is representative of the body as a whole. Macrodiamond grade determinations on individual kimberlite bulk samples recovered from the shaft will enable Shore to constrain the grades of kimberlite types encountered in previous drill programs.

After analyzing a number of alternative methods, Shore elected to freeze the shaft area before the commencement of shaft sinking to ensure the stability of the till overburden and to create a safe working environment. Layne Christensen Canada Ltd. completed 22 freeze holes drilled in a circular pattern to a depth of 130 m with an approximate 4 m radius from the shaft center, as well as two additional outlying temperature-monitoring holes.

The kimberlite recovered from the Star body will be processed on-site in a modular diamond recovery plant, designed and built by Bateman Engineering. The plant components include a Dense Media Separator (DMS), x-ray sortex, and grease table in order to produce diamond-rich concentrates that will be sorted in a secure facility. Additional site security, including 24-hour security guards and camera surveillance, will be implemented during the assembly of the diamond recovery plant and will be in place for all kimberlite processing.

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Abstracts for Other Papers Appearing in the Summary of Investigations 2003, Volume 2 (CD-ROM)

Stratigraphic and Structural Investigations of the Thluicho Lake Group, Zemlak Domain, Rae Province (Uranium City Project)

R. Hunter [1], K.M. Bethune [1], and K.E. Ashton

Hunter, R., Bethune, K.M., and Ashton, K.E. (2003): Stratigraphic and structural investigations of the Thluicho Lake Group, Zemlak Domain, Rae Province (Uranium City Project); *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-2.

Abstract

The Thluicho Lake Group is a sequence of Paleoproterozoic siliciclastic rocks overlying a mylonitized, upper amphibolite facies basement complex in the Zemlak Domain north of Lake Athabasca. This paper reports preliminary results of stratigraphic and structural analysis of this group in the Waterloo-Wellington lakes area, about 15 km west of Uranium City, where it is preserved in a kilometre-scale structural basin. Preliminary inspection of the contact between the Thluicho Lake Group and underlying rocks verifies previous observations that, although locally inverted due to deformation, there is a significant angular discordance between the basement and the Thluicho Lake Group. Above the basement contact, the map-scale interrelationship between stratigraphy and structure supports the interpretation of a single (basal) conglomerate unit that has been repeated by folding. The conglomerate is overlain by the following units: pebbly arkose, arkose, and graded arkose/argillite indicating an overall fining upward succession. The generally arkosic nature of the rocks, along with the make-up of the clast population in the basal conglomerate (massive and foliated granite, gneiss, mylonite and minor greenschist-facies, fine-grained sedimentary clasts), is consistent with deposition in an intracontinental setting. Based on lithological and temporal similarities, the group has been tentatively correlated with the Nonacho Group, a continental clastic succession that lies about 120 km northwest of the study area.

The Thluicho Lake Group was affected by three, and possibly four, phases of deformation and associated greenschist-facies metamorphism. The first set of folds, recognized mainly by repetition of units, had axial surfaces that trended approximately east-west. These early structures were subsequently deformed by northeast-trending F2 folds, producing a regional-scale fold with "Z" asymmetry. A third episode of deformation is inferred from a set of relatively open F3 folds with axes that plunge gently to moderately southward. A set of ca. 1.82 Ga east-trending diabase dykes cuts first- and second-generation folds, but was affected by the third deformational event. No evidence has been found thus far for a previously postulated fourth generation of folding. The youngest structures include a system of brittle to brittle-ductile subvertical faults and related fractures with two predominant orientations: east-northeast and northeast.

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Preliminary Results of the 2002-2003 Saskatchewan Industry and Resources Geochronology Program

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Heaman, L.M., Hartlaub, R.P., Ashton, K.E., Harper, C.T., and Maxeiner R.O. (2003): Preliminary results of the 2002-2003 Saskatchewan Industry and Resources geochronology program; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-3.

Abstract

Conventional ID-TIMS U-Pb analyses have provided preliminary results for four samples collected from northern Saskatchewan. A probable volcaniclastic rock from the base of the Murmac Bay Group in the Beaverlodge Domain has yielded a 2327 ±14 Ma date, indicating that part or all of the succession may be much younger than the Archean age previously inferred. An 1898 ±3 Ma date obtained from an upper amphibolite facies gabbro suggests that the high-grade metamorphic event overprinting the adjoining Zemlak Domain to the west is synchronous with previously determined 1.91 to 1.90 Ga thermotectonism in the Beaverlodge Domain. A 1751 ±2 Ma date from a pink fluorite-bearing porphyritic granite in the northern Mudjatik Domain implies southward extension of the Nueltin Granite suite into northern Saskatchewan. A megacrystic monzonite from the southern Peter Lake Domain has yielded a 2540 ±1 Ma date, providing a minimum age for the Warner Lake gabbroic suite, migmatitic supracrustal rocks, and the regional upper amphibolite facies metamorphic overprint.

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Petrography and Geochemistry of the Love Lake Leucogabbro, Swan River Complex, Peter Lake Domain, Northern Saskatchewan

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Leatherdale, S.M., Maxeiner, R.O., and Ansdell, K.M. (2003): Petrography and geochemistry of the Love Lake Leucogabbro, Swan River Complex, Peter Lake Domain, northern Saskatchewan; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper A-8.

Abstract

The Love Lake Leucogabbro is a large mafic to ultramafic intrusion within the southwestern Swan River Complex of the mostly Archean Peter Lake Domain. This pluton comprises a main phase described by previous workers as leucogabbro and several minor mafic to ultramafic ones. This paper summarizes the results of a B.Sc. Honours thesis on the petrography, geochemistry, and metamorphism of the Love Lake Leucogabbro. Petrographic and electron microprobe analyses showed that the phase of the pluton is amphibolitized leucogabbronorite; leucogabbro, gabbro, and clinopyroxene norite are minor components. The Love Lake Leucogabbro has been affected by an upper amphibolite facies metamorphic event, likely during the Archean, as well as a later lower amphibolite to upper greenschist facies event, probably coinciding with the Paleoproterozoic Trans-Hudson Orogeny.

Whole rock major and trace element analyses of the gabbronorite suggest it was derived from a cogenetic magma source. Binary mobility diagrams suggest that the high field strength elements, and surprisingly, many of the large ion lithophile elements, remained immobile. Although a subduction zone-like signature apparently characterizes the gabbronorite, this signature might also be attributed to fractional crystallization, crustal contamination, or slab-derived metasomatism of the mantle source, and does not necessarily reflect direct evolution within a slab-derived collisional tectonic regime.

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Diamondiferous Kimberlites of Central Saskatchewan Project: Update

S.E. Harvey, J-P. Zonneveld [1], and B.A. Kjarsgaard [2]

Harvey, S.E., Zonneveld, J-P., and Kjarsgaard, B.A. (2003): Diamondiferous kimberlites of central Saskatchewan Project: Update; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper C-1.

Abstract

Additional research has been completed on the partnered multi-disciplinary federal-provincial-industry-university "Diamondiferous Kimberlites of Central Saskatchewan" project. Several more cores have been logged from the Fort à la Corne Joint Venture's 140/141 kimberlite and Shore Gold's Star kimberlite. Results from micropaleontology studies, U-Pb perovskite dating, 2-D and 3-D seismic studies and downhole logging have been integrated with volcanological and sedimentological data derived from the detailed core logging. New 2- and 3-D models of the architecture of the two kimberlites are being developed. These are revealing that both kimberlites had a complex emplacement history characterized by multiple eruptive events each with a spectrum of distinct facies.

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Field Investigations of Airborne Gamma Ray Spectral Domain D, NEA-IAEA Test Area, Eastern Athabasca Basin

J.E. Campbell, R.B.K. Shives [1], and R.A. Klassen [1]

Campbell, J.E., Shives, R.B.K., and Klassen, R.A. (2003): Field investigations of airborne gamma ray spectral domain D, NEA-IAEA test area, eastern Athabasca Basin; *in* Summary of Investigations 2003, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2003-4.2, CD-ROM, Paper D-2.

Abstract

Previous work in the NEA-IAEA test area, eastern Athabasca Basin, defined spectral domains based on prominent K-eU-eTh spectral patterns in airborne gamma ray survey data. Within the basin, these domains reflect variation in sandstone lithology, bedrock structures, and proportions of intra-(sandstone) and extra-(crystalline) basinal glacial detritus. A narrow, southwest-trending curvilinear K- and eU-rich trend referred to as the D domain, or "ribbon", is enigmatic. The "ribbon" has previously been modeled as a dispersal train of granitic boulders related to an older ice flow direction, and as the surface expression of local bedrock alteration. Preliminary work suggested that the "ribbon" domain spectral patterns may reflect a poly-genetic Quaternary feature.

Field investigations in 2003 focused on determining the source(s) of the spectral signatures of the D domain. Three additional sampling transects across the "ribbon" were completed up-ice of the previous Black Lake Road transect.

The D domain does not appear to have any geomorphic association, as it crosses a variety of surficial deposits, including veneer (<2 m thick) and blanket (>2 m thick) ground moraine, streamlined moraine, and stagnant ice hummocky moraine. The contact between domain D and the eTh-rich A domain is marked by a sharp compositional change in the till. Although compositionally variable, the surface material in D domain is predominantly crystalline-rich till. The greatest variability in sandstone versus crystalline composition is associated with the hummocky moraine. The highest proportion of crystalline detritus is found in the ground moraine. At several sites within the D domain, a veneer of crystalline rich till overlies a more sandstone-rich till. This is opposite to the regional occurrence of sandstone-rich till capping crystalline-rich till.

Preliminary field observations indicate the source of the "ribbon"'s radioactive element signature is K-U-(and Th) bearing megacrystic calc-alkaline boulders which are more abundant in domain D relative to other spectral domains, including the moderately K- and eU-rich B domain. These boulders are probably derived from the Late Hudsonian porphyritic calc-alkaline granites and related granitoids in the western Wollaston Domain. No field evidence of a sandstone-derived source for the radioactive element signature of the "ribbon" was found.

The D domain is a Quaternary feature composed predominantly of crystalline detritus derived from outside the basin. Physical and compositional characteristics of the "ribbon" feature cannot be explained by simple down-ice glacial dispersal mechanisms. The genesis of this Quaternary feature is unresolved but appears to be at least in part related to the late southerly ice flow.

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